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Final Best Demonstrated Available Technology (BDAT) Background Document for Barium Wastes (D005 and P013) Volume 20

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FINAL
BEST DEMONSTRATED AVAILABLE TECHNOLOGY (BDAT) BACKGROUND DOCUMENT FOR

BARIUM WASTES
(D005 AND P013)

Larry Rosengrant, Chief
Treatment Technology Section

Rhonda M. Craig
Project Manager

U.S. Environmental Protection Agency
401 M Street, S.W.
Office of Solid Waste
Washington, DC 20460

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Versar personnel involved in the preparation of this document included Mr. Jerome Strauss, Program Manager; Mr. Stephen Schwartz, Assistant Program Manager; Mr. James Berkes and Ms. Kathryn Jones, Staff Engineers; Ms. Justine Alchowiak, Quality Assurance Officer; Ms. Martha Martin, Technical Editor, and Ms. Sally Gravely, Program Secretary.

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1. INTRODUCTION AND SUMMARY

Pursuant to section 3004(m) of the Resource Conservation and Recovery Act (RCRA) as enacted by the Hazardous and Solid Waste Amendments (HSWA) on November 8, 1984, the Environmental Protection Agency (EPA) is proposing treatment standards based on the best demonstrated available technology (BDAT) for barium in characteristic wastes identified in 40 CFR 261.24 as waste code D005 and for commercial chemical product wastes identified in 40 CFR 261.33 as waste code P013 - barium cyanide. Treatment standards for cyanides contained in P013 - barium cyanide were promulgated in the Final Rule for Second Third Wastes (54 FR 26614, June 23, 1989). Compliance with treatment standards is a prerequisite for placement of wastes in facilities designated as land disposal units as defined in 40 CFR 268.2. The effective date of final treatment standards for barium in D005 and P013 wastes will be August 8, 1990.

This background document presents the Agency's technical support and rationale for developing regulatory standards for barium-containing wastes. Sections 2 through 6 present waste-specific information for the D005 wastes. Section 2 describes the industries affected by the regulation of D005 wastes, explains the processes generating these wastes, and presents available waste characterization data. Section 3 specifies the applicable and demonstrated treatment technologies for D005 wastes. Section 4 presents available performance data for the demonstrated technologies, including data upon which treatment standards are based. Section 5 contains analyses of the performance data to determine BDAT, and Section 6 contains the determination of the proposed treatment standards for the regulated constituent (barium). Section 7 discusses the listed waste P013 - barium cyanide and details the development of the treatment standard for these wastes.

The land disposal restrictions program and promulgated BDAT methodology are more thoroughly described in two additional documents: Methodology for Developing BDAT Treatment Standards (USEPA 1989a) and Generic Quality Assurance Project Plan for Land Disposal Restrictions Program ("BDAT") (USEPA 1988a). The petition process to be followed in requesting a variance from the treatment standards is discussed in the methodology document.

Treatment standards are being promulgated for the wastewater and nonwastewater forms of D005 and P013 wastes. For the purposes of determining BDAT and developing treatment standards, a wastewater is defined by the Agency as a waste containing less than 1 percent (weight basis) total suspended solids* (TSS) and less than 1 percent (weight basis) total organic carbon (TOC). Wastes not meeting this definition must comply with the treatment standards for nonwastewaters.

BDAT for D005 wastewaters is lime precipitation followed by sedimentation and filtration. EPA recognizes the diversity of wastes that qualify as hazardous under the D005 classification. Because of this diversity, EPA has chosen to regulate D005 wastewaters at the characteristic level of 100 mg/l. EPA believes even the most difficult to treat D005 wastewaters can be treated to this level.

BDAT for P013 wastewaters is lime precipitation followed by sedimentation and filtration. These technologies were part of the treatment train used as BDAT for regulating the cyanide content of P013 (USEPA 1989c).

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* The term "total suspended solids" clarifies EPA's previously used terminology of "total solids" and "filterable solids." Specifically, the quantity of total suspended solids is measured by Method 209C (Total Suspended Solids Dried at 103°C to 105°C) in Standard Methods for the Examination of Water and Wastewater, 16th Edition (APHA, AWWA, and WPCF 1985).

However, EPA is not regulating P013 wastewaters for barium but only for cyanides (EPA 1989c). EPA believes that the treatment train used to treat P013 wastewaters for cyanides will effectively reduce the concentration of barium at the same time.

BDAT for D005 nonwastewaters is stabilization. The data, presented in Section 4, show that a treatment standard of 52 mg/l barium is achievable for nonwastewater TCLP leachates. Acid or water leaching of D005 nonwastewaters is expected to yield a nonwastewater residual also capable of the same treatability (and a wastewater residual that would require treatment by chemical precipitation). However, there are no data available to EPA on this form of nonwastewater treatment. Because EPA recognizes the diversity of wastes that qualify as hazardous under the D005 classification, EPA has chosen to regulate D005 nonwastewaters at the characteristic level of 100 mg/l, rather than 52 mg/l as shown above. EPA believes even the most difficult to treat D005 nonwastewaters can be treated to this level.

BDAT for P013 nonwastewaters is stabilization. EPA is promulgating a treatment standard of 52 mg/l for barium in P013 nonwastewaters TCLP leachate based on performance data presented in Section 4. The treatment standards for D005 and P013 barium wastes are listed in Tables 1-1 and 1-2, respectively.

Table 1-1 BDAT Treatment Standards for D005 Wastes

Constituent	Maximum for any single grab sample	
	Wastewater (mg/l)	Nonwastewater TCLP (mg/l)
Barium	100	100

Table 1-2 BDAT Treatment Standards for P013 Wastes

Constituent	Maximum for any single grab sample	
	Wastewater (mg/l)	Nonwastewater TCLP (mg/l)
Barium	NR[a]	52

NR = not regulated.

[a]P013 wastewaters are not being regulated for barium but are being regulated for cyanides. See the Best Demonstrated Available Technology (BDAT) Background Document for Cyanide Wastes (USEPA 1989c).

2. INDUSTRIES AFFECTED AND WASTE CHARACTERIZATION

As defined in 40 CFR 261.24, D005 wastes are wastes that exhibit the characteristic of EP toxicity for barium. In other words, D005 wastes have a barium concentration of greater than 100 mg/l, as measured by the TCLP (Toxicity Characteristic Leaching Procedure), 51 FR 40643, November 7,
1986. Section 2.1 describes the industries affected by the land disposal restrictions for D005 wastes and describes the processes identified by EPA that may generate these wastes. Section 2.2 summarizes the available waste characterization data for D005 wastes. Section 2.3 uses the Agency's analyses of the sources of D005 wastes and waste composition to divide D005 wastes into treatability groups.

2.1 Industries Affected and Process Descriptions

The industries affected by the land disposal restrictions for D005 wastes are (1) the inorganic chemicals industry, which produces various inorganic barium compounds, and (2) industries that use barium compounds to manufacture various products. The barium compounds manufactured and used by these industries are discussed below.

2.1.1 Production of Inorganic Barium Compounds

Barium does not occur in its free state in nature. Its compounds are widely distributed in the earth's crust in igneous rocks, sandstone, and shale. The major barium minerals are barium sulfate (baryte) and barium carbonate (witherite). Barium sulfate is mined in the United States to produce either barium metal or its compounds.

The initially mined barium sulfate is usually reduced to barium sulfide (also known as black ash) by calcining with coke in a rotary kiln at temperatures of 1000 to 1250°C in the oxygen-free environment. The resultant ash is quenched in water to dissolve the barium sulfide to

provide a 12 to 30 percent solution. The resultant solution may be used to produce other barium salts such as barium carbonate, barium chloride, barium nitrate, and barium sulfate. The following are examples of reactions used to make barium carbonate and barium sulfate, respectively:

$$BaS + Na_2CO_3 \rightarrow BaCO_3 + Na_2S$$
$$BaS + Na_2SO_4 \rightarrow BaSO_4 + Na_2S$$

The current manufacturers of barium compounds are listed in Table 2-1 at the end of this section.

2.1.2 Users of Inorganic Barium Compounds

Barium carbonate is the most important and most widely used barium compound. It is utilized in the manufacture of bricks, in ceramics manufacture, in oil drilling fluids as "muds" and lubricating compound precursors, in the precipitation of "synthetic" barium sulfate for photographic and medicinal end uses, and in the manufacture of glass. Barium chloride is used in production of pigments and colors. Barium nitrate is widely used in the pyrotechnics industry for the production of tracer bullets, flares, and detonators. Other barium compounds are used as lubricating oils and greases and as metallic soaps. Some of the black ash is processed to provide barium metal, which is highly reactive and is used as a "getter" in electronics equipment and vacuum tubes.

2.2 Waste Characterization

The Agency has information from 57 facilities generating D005 wastes. These facilities reported generating 67 D005 waste streams in 1985. This information was obtained from EPA's 1986 National Survey of Hazardous Waste Generators (the Generator Survey, USEPA 1986b). Forty-eight of the waste streams generated were nonwastewater forms of D005; ten of the waste streams generated were wastewaters. For the

remainder of the waste streams (i.e., nine waste streams), generators reported that the form of the waste generated was indeterminable. Barium concentrations reported by facilities were as follows:

Ba Concentration in Waste:	No. of Facilities:
50 - 75%	1
25 - 50%	5
10 - 25%	3
1 - 10%	2
0.1 - 1%	8
500 ppm - 0.1%	2
100 - 500 ppm	13
10 - 100 ppm	5
Unknown	18

Most D005 wastes are generated in inorganic matrices. However, Generator Survey data indicate that D005 wastes may sometimes be present in a matrix containing significant quantities of organic constituents such as F001-F005 spent solvents or waste oils. The levels of organics reported in D005 waste streams by two facilities were 98 percent and 25 percent, respectively.

2.3 Determination of Waste Treatability Groups

EPA believes that in some cases, wastes with the same waste code but produced in different processes in an industry, or in different industries, may not be treatable to similar concentrations using the same technologies. In such instances, the Agency may subdivide a waste code into several treatability groups. This is done when the chemical forms of the wastes are different and the wastes require different treatments or combinations of treatments. For example, inorganic and organometallic compounds containing the same metals frequently require different types of treatment.

Based on a careful review of information on the generation of D005 wastes and of available waste characterization data, the Agency determined

that all D005 wastewaters form a single treatability group. The Agency also determined the same to be true for D005 nonwastewaters.

The concentration of barium in D005 wastes is dependent on the waste type, the particular production process employed, and the specifics of the treatment process used. However, all D005 wastewaters are expected to be treatable to similar levels by use of the same technologies. In terms of waste characteristics that affect treatment performance, the Agency believes that the presence of BDAT list metals will not affect the treatability of dissolved barium in wastewaters. While high concentrations of organics in wastewater might affect the performance of barium treatment. D005 wastewaters are not expected to have high concentrations of organics, (because EPA's definition of wastewaters limits total organic carbon to less than 1% by weight).

The Agency also believes that all D005 nonwastewaters are expected to be treatable to similar levels by use of the same technologies. However, the Agency recognizes the possibility that D005 nonwastewaters containing high levels of organics could be generated. The Agency, therefore, solicited information on whether such wastes actually exist, the concentration of barium and organics within such wastes, and treatment data. The Agency found that these wastes do exist, but treatment data were not submitted. However, incineration has been shown to destroy organic wastes and would be expected to do so for organobarium nonwastewaters. If the potential exists for the volatilization of barium into the gas stream, air pollution control devices would be required. Incineration of organobarium wastes yields ash and scrubber water inorganics that can be treated in the same way as their inorganic barium-containing counterparts. Therefore, the Agency is including organobarium nonwastewaters in the same treatability group as other barium-containing nonwastewaters.

Table 2-1 Current Manufacturers of Barium Chemicals

Manufacturer's name	Manufacturer's location	Barium compound name
Barium & Chemicals, Inc.	Steubenville, OH	Barium acetate Barium bromide Barium carbonate Barium chlorate Barium chloride Barium chromate Barium fluoride Barium hydroxide, anhydrous Barium hydroxide, octahydrate Barium iodide Barium nitrate Barium nitrite Barium oxalate Barium oxide Barium perchlorate Barium peroxide Barium silicide Barium silcofluoride Barium sulfate, natural (barytes) Barium sulfate, synthetic (blanc fixe) Barium sulfide Barium tartrate
Procter & Gamble Co. J.T. Baker, Inc. (sub)	Phillipsburg, NJ	Barium acetate Barium carbonate Barium chloride Barium hydroxide, octahydrate Barium nitrate Barium sulfate, synthetic (blanc fixe)

Table 2-1 (continued)

Manufacturer's name	Manufacturer's location	Barium compound name
Kaisertech Limited Harshaw/Filtrol Ptrshp.	Solon, OH	Barium calcium fluoride Barium strontium niobate
Chemical Products Corp.	Cartersville, GA	Barium carbonate Barium chloride Barium sulfide
General Electric Corp. Components/Quartz Mktg.	Cleveland, OH	Barium carbonate Barium nitrate Barium titanate
GTE Corporation Chem & Metalurgical Div.	Towanda, PA	Barium carbonate Barium phosphate, dibasic
G. Frederick Smith Chemical Company	Columbus, OH	Barium chloride Barium diphenylamine sulfonate Barium perchlorate
National Industrial Chemical Company	Chicago, IL	Barium chromate
Wayne Pigment Corp.	Milwaukee, WI	Barium chromate
Nuodex Inc.	Elizabeth, NJ	Barium 2-ethylhexanoate
Hoosier Magnetics, Inc.	Washington, IN	Barium ferrite
Hoosier of New York	Ogdensburg, NY	Barium ferrite
Hoosier of Ohio	Toledo, OH	Barium ferrite

Table 2-1 (continued)

Manufacturer's name	Manufacturer's location	Barium compound name
Kaisertech Ltd.	Cleveland, OH & Solon, OH	Barium fluoride
Pennwalt Corp. Ozark-Mahoning Co.	Tulsa, OK	Barium fluoride
Deepwater, Inc.	Carson, CA	Barium iodate Barium iodide
Strem Chemicals Inc.	Newburyport, MA	Barium isopropoxide
Union Carbide Amerchol Corp.	Edison, NJ	Barium lanolate
Buckman Laboratories	Memphis, TN	Barium metaborate
Croton Corp.	South Plainfield, NJ	Barium nitrate
Hummel Chemical Co.	South Plainfield, NJ	Barium nitrate Barium oxalate Barium peroxide
Akzo America, Inc. Interstab Chemicals	New Brunswick, NJ	Barium salt of nonylphenol
Ferro Corp. Transelco Division Electronic Ceramic Matls.	Penn Yan, NY	Barium stannate Barium titanate Barium zirconate
Tam Ceramics	Niagara Falls, NY	Barium stannate Barium titanate Barium zirconate Barium zirconium silicate

Table 2-1 (continued)

Manufacturer's name	Manufacturer's location	Barium compound name
The Norac Co., Inc. Mathe Division	Lodi, NJ	Barium stearate
Nuodex, Inc.	Piscataway, NJ	Barium stearate
Plastic Spec & Technol Synthetic Products Co.	Cleveland, OH	Barium stearate
Witco Corp., Organics Division	Chicago, IL	Barium stearate
Chemtech Industries, Inc. Harstan Division	Brooklyn, NY	Barium sulfamate
Cyprus Minerals Co. Cyprus Metec Corp.	Cartersville, GA	Barium sulfate, natural (barytes)
Pennwalt Corp. Ozark-Mahoning Co.	Rosiclare, IL	Barium sulfate, natural (barytes)
Pfizer, Inc Min, Pig & Mtls. Div.	Easton, PA	Barium sulfate, natural (barytes) Barium sulfate, synthetic (blanc fixe)
Whittaker, Clark & Daniels	South Plainfield, NJ	Barium sulfate, natural (barytes) Barium sulfate, synthetic (blanc fixe)
Alex Chemical Co.	Shenandoah, PA	Red 53:1 pigment (Red Lake C, Ba salt) Red 57 pigment (Lithol Rubine, Ba salt)

Table 2-1 (continued)

Manufacturer's name	Manufacturer's location	Barium compound name
Allied Signal, Inc. Ridgeway Color Co. (sub)	Cincinnati, OH	Red 53:1 pigment (Red Lake C, Ba salt)
Apollo Colors	Rockdale, IL	Red 53:1 pigment (Red Lake C, Ba salt) Red 57 pigment (Lithol Rubine, Ba salt)
BASF Corp. Pigments Business	Holland, MI	Red 53:1 pigment (Red Lake C, Ba salt)
Chromatic Color Corp.	Elizabethtown, KY	Red 53:1 pigment (Red Lake C, Ba salt)
Dic Acquisition Group Sun Chemical Corp. Pigments Div.	Cincinnati, OH & Rosebank, NY	Red 53:1 pigment (Red Lake C, Ba salt)
Hilton Davis Co.	Cincinnati, OH	Red 53:1 pigment (Red Lake C, Ba salt)
Hoechst Celanese Corp.	Coventry, RI	Red 53:1 pigment (Red Lake C, Ba salt)
Industrial Color Inc.	Joliet, IL	Red 53:1 pigment (Red Lake C, Ba salt)
Kaisertech Ltd. Harshaw/Filtrol Ptrshp	Louisville, KY	Red 53:1 pigment (Red Lake C, Ba salt) Red 57 pigment (Lithol Rubine, Ba salt)
H. Kohnstamm & Co., Inc.	Camden, NJ	Red 53:1 pigment (Red Lake C, Ba salt)

Table 2-1 (continued)

Manufacturer's name	Manufacturer's location	Barium compound name
Magruder Color Corp	Elizabeth, NJ	Red 53:1 pigment (Red Lake C, Ba salt)
Max Marx Color Corp.	Irvington, NJ	Red 53:1 pigment (Red Lake C, Ba salt)
Paul Uhlich & Co., Inc.	Hastings-on-Hudson, NY	Red 53:1 pigment (Red Lake C, Ba salt)
Bayer, USA Inc. Mobay Corp. (sub)	Haledon, NY	Red 57 pigment (Lithol Rubine, Ba salt)
Binney & Smith, Inc.	Easton, PA	Red 57 pigment (Lithol Rubine, Ba salt)
Heubach Inc.	Newark, NJ	Red 57 pigment (Lithol Rubine, Ba salt)
Industrial Color Inc.	Joliet, IL	Red 57 pigment (Lithol Rubine, Ba salt)

Reference: SRI 1989.

3. APPLICABLE AND DEMONSTRATED TREATMENT TECHNOLOGIES

This section identifies the treatment technologies that are applicable to the wastewater treatability group and to the nonwastewater group. This section also explains the determination of which, if any, of the applicable technologies can be considered demonstrated for the purpose of establishing BDAT.

To be applicable, a technology must be theoretically usable to treat the waste in question or to treat a waste that is similar in terms of the parameters that affect treatment selection. For detailed descriptions of the technologies applicable to these wastes, or for wastes judged to be similar, see EPA's Treatment Technology Background Document (USEPA 1989b). To be demonstrated, the technology must be employed in full-scale operation for the treatment of the waste in question or a similar waste. Technologies available only at pilot- and bench-scale operations are not considered in identifying demonstrated technologies.

3.1 Applicable Treatment Technologies

The applicable technologies for treatment of barium wastes are those that could reduce the concentration of barium or reduce the leachability of barium in the treatment residual.

3.1.1 Applicable Technologies for Wastewaters

Barium wastewaters are typically generated from the inorganic chemicals industry. The two technologies identified as applicable for barium wastewaters are chemical precipitation and ion exchange. These technologies are described below.

(1) Chemical precipitation. Chemical precipitation typically involves addition of lime (calcium hydroxide) or caustic (sodium hydroxide) to the wastewater solution. This results in the precipitation of barium as barium hydroxide. Barium, however, is usually precipitated as barium sulfate using sodium sulfate, ferric sulfate, or aluminum sulfate, or precipitated as barium carbonate at a pH of 10-10.5 with lime used for pH adjustment. These precipitation techniques are usually used for barium-containing wastes because barium sulfate and barium carbonate are the most insoluble barium compounds. Metal salts precipitated from solution are usually gravity settled and/or filtered. The collected solids may then be further treated by a technology applicable to nonwastewaters prior to disposal. The treated wastewater may be further treated for other components or discharged. Chemical precipitation is further discussed in the Treatment Technology Background Document (USEPA 1989b).

(2) Ion exchange. This technology is applicable to treatment of wastewaters containing relatively low concentrations of dissolved metals. The metal must be in a soluble ionic form in order to be removed. The waste is passed through a bed of ion exchange resin beads. The resin adsorbs the soluble ions, thus removing them from solution. Ion exchange produces both a wastewater residual (from regeneration of the ion exchange resin) and a nonwastewater residual (the spent ion exchange resin). The spent regenerate solutions (usually acid solutions) are more concentrated than the original untreated waste (though much lower in volume) and must be treated to remove metals by chemical precipitation followed by filtration if the regenerate solution is not recyclable. Ion exchange is discussed in detail in the Treatment Technology Background Document (USEPA 1989b).

3.1.2 Applicable Technologies for Nonwastewaters

Barium nonwastewaters typically are generated as inorganic solids and sludges from treatment of wastewaters, or as ash or slag from thermal processes such as incineration or metallurgical processes. The technologies that are applicable to barium nonwastewaters are stabilization, chemical precipitation, leaching with acid or water, and incineration. These technologies are described below.

(1) Stabilization technologies. Stabilization treatment technologies are designed to reduce the leachability of metals in the treated waste compared to that in the untreated waste. These technologies require mixing the waste with lime, fly ash mixtures, cement, concrete mixtures or other formulations (both proprietary and nonproprietary). Water is then added, and the mixture sets into a solid mass. Stabilization technologies are discussed in detail in the Treatment Technology Background Document (USEPA 1989b).

(2) Chemical precipitation. Chemical precipitation technologies are normally used to treat wastewaters. They may also be used, however, to treat suspensions of solids in water. Such suspensions may meet the definition of nonwastewaters (i.e., greater than 1 percent total suspended solids). These technologies were previously discussed in Section 3.1.1 on wastewaters.

(3) Leaching Processes. Leaching is the removal of a soluble fraction, in the form of a solution, from an insoluble, permeable solid phase with which the soluble phase is associated. A liquid leaching agent is mixed with the nonwastewater to dissolve the soluble fraction. The leaching agent may be acid or water, but they both operate using the same principle. Acid or water leaching can often be applied to wastes containing hazardous metals (Green 1984).

(4) Incineration. Incineration is a destruction technology used for organic or organometallic nonwastewaters, in which energy, in the form of heat, is transferred to the waste to destabilize chemical bonds and destroy hazardous organic constituents. In a fluidized bed incinerator, waste is injected into the fluidized bed material (generally sand and/or incinerator ash), where it is heated to its ignition temperature. Heat energy from the combustion reaction is then transferred back to the fluidized bed. Ash is removed periodically during operation and during bed change-outs.

In a rotary kiln incinerator, wastes are fed into the elevated end of the kiln. The rotation of the kiln mixes the wastes with hot gases, heating the wastes to ignition temperature. Ash is removed from the lower end of the kiln. Combustion gases from the kiln enter the afterburner for complete destruction of waste constituents. Other wastes may be injected into the afterburner for treatment.

In a liquid injection incinerator, atomized liquid wastes are injected into the incinerator. In general, only wastes with low ash content are amenable to liquid injection incineration; therefore, this technology generally does not generate an ash residual.

Combustion gases from any incinerator are fed to a scrubber system to cool and to remove entrained particulates and acid gases. With the exception of liquid injection incineration, two residuals are generated by incineration processes: ash and scrubber water.

3.2 Demonstrated Treatment Technologies

3.2.1 Demonstrated Technologies for Wastewaters

Chemical precipitation. This technology has been demonstrated on a commercial basis to treat a wide variety of wastewaters containing metal constituents, such as the listed waste K062. K062 contains relatively high concentrations of metals such as cadmium and lead. Although the K062 waste did not have barium, chemical precipitation is universally applied to all forms of metal-containing wastewaters. The use of chemical precipitation to treat K062 wastewaters is described in the K062 background document (USEPA 1988f).

3.2.2 Demonstrated Technologies for Nonwastewaters

(1) Stabilization. The use of stabilization to treat barium wastes has been demonstrated (HWTC 1989a, 1989b). Relatively high concentrations of barium have been treated by stabilization using proprietary reagents. This technology has been demonstrated on a commercial basis to treat metal-bearing wastes such as the listed wastes K061 and F006. These wastes contain relatively high concentrations of metals such as cadmium and lead. The use of stabilization to treat these wastes is described in the K061 background document (USEPA 1988b) and the F006 background document (USEPA 1988c).

(2) Chemical precipitation. As previously discussed, chemical precipitation technologies are normally used to treat wastewaters. They may be used, however, to treat suspensions of solids in water. These technologies are discussed further in the wastewater Section 3.2.1.

(3) Leaching Processes. While there are no data available to EPA on acid or water leaching of D005 nonwastewaters, acid or water leaching has been demonstrated on wastes in solid or slurry form containing hazardous metals (USEPA 1989b).

(4) Incineration. This technology is demonstrated for treatment of many hazardous wastes containing both organic and metal constituents. Incineration for organobarium wastes yields ash (nonwastewater residue) and scrubber water (wastewater) containing inorganic barium. These residues can be treated like other nonwastewaters and wastewaters described above.

4. PERFORMANCE DATA

This section presents relevant data on the performance of demonstrated technologies in treating listed wastes containing barium in concentrations expected to be found in D005 wastes. These data are used elsewhere in this document for determining which technologies represent BDAT (Section 5) and for developing treatment standards (Section 6). Eligible data, in addition to full-scale demonstration data, may include data developed at research facilities or obtained through other applications at less than full-scale operation, as long as the technology is demonstrated in full-scale operation for a similar waste as defined in Section 3.

Performance data that are required for determining treatment standards include the untreated and treated waste concentrations for a given constituent, the values of operating parameters that were measured at the time the waste was being treated, the values of relevant design parameters for the treatment technology, and data on waste characteristics that affect performance of the treatment technology.

Where data are not available on the treatment of the specific wastes of concern, the Agency may elect to transfer data on the treatment of a similar waste or wastes, using a demonstrated technology. To transfer data from another waste category, EPA must find that the wastes covered by this background document are no more difficult to treat (based on the waste characteristics that affect performance of the demonstrated treatment technology) than the treated wastes from which performance data are being transferred.

4.1 Performance Data for Wastewaters

The reference manual Industrial Wastewater Treatment Technology (Patterson 1985) contains performance data on the treatment of barium wastes. The technologies used for barium treatment include chemical precipitation of barium as barium sulfate, barium carbonate, and barium hydroxide, as well as treatment by ion exchange. The concentration of barium in the untreated wastes ranged from 2,100 mg/l to 0.5 mg/l. Percent removal ranged from 11 to >99 percent. The waste containing 2,100 mg/l of barium was the only waste containing barium above the EP toxicity level of 100 mg/l. Treatment by sulfate precipitation reduced the barium concentration in this waste to 1.78 mg/l.

The poorest barium removal was 11 percent, but the untreated waste concentration contained a small concentration of barium. Other information available from the literature (Kirkpatrick 1978, Versar 1980) also indicates that barium may be chemically precipitated as barium sulfate or barium carbonate. Chemical precipitation as sulfate or carbonate is an effective treatment for barium because of the relative insolubility of barium sulfate in water and weak acids, and barium carbonate in water. The solubilities of some barium compounds are presented below:

Compound Name	Solubility in Water (mg/l)	Temperature (°C)
Barium Acetate	588,000	0
Barium Formate	262,000	0
Barium Carbonate	20	20

Compound Name	Solubility in Water (mg/l)	Temperature (°C)
Barium Chloride	317,000	0
Barium Bromide	922,000	0
Barium Iodide	170,000	0
Barium Hydroxide	17,000	0
Barium Nitrate	50,000	0
Barium Sulfate	3.36	50
Barium Hydrosulfide	326,000	0
Barium Sulfite	197	20

Sources: Kirkpatrick 1978, Weast 1977.

Additional wastewater data, primarily from EPA's Office of Water, were analyzed. Average influent and effluent concentrations were given. For two similar chemical precipitation technologies, these data show treatment from 2.8 mg/l to 42 mg/l for one technology and from 2.8 mg/l to 0.28 mg/l for the other technology, both technologies being a combination of sedimentation, lime precipitation, and filtration. Further information on these data, including the sources of the data and the treatment technologies used, can be found in the Best Demonstrated Available Technology (BDAT) Background Document for Wastewaters Containing BDAT List Constituents (USEPA 1990), and these data are presented in Table 4-1 at the end of this section.

4.2 Performance Data for Nonwastewaters

The Agency believes that the data discussed in Section 4.1 for treatment of wastewaters by chemical precipitation as sulfate or carbonate also apply to D005 nonwastewaters; i.e., precipitates of barium sulfate and carbonate are so insoluble that they are likely not to require additional treatment.

Stabilization data were submitted in comments on the proposed treatment standard (HWTC 1989a, 1989b). The performance data are presented in Table 4-2. The reagents are proprietary.

Stabilization data were also received from commenters (Tricil 1989, Waste Management, Inc. (WMI) 1989, and Vision-Ease 1989). These data were not used in calculating the treatment standard because no untreated waste concentrations were included that correspond to the treated values. For Tricil the data showed treatment values of 0.4 to 2.18 mg/l EP for the treated waste; for WMI, values of 0.26 to 561 mg/l for TCLP for the treated waste; and for Vision-Ease, values of 3.2 to 150 mg/l EP for the treated waste. All three commenters used stabilization as a method of treatment.

EPA's methodology for developing treatment standards requires that untreated concentrations of hazardous constituents be reported in order to determine whether treatment actually occurred (USEPA 1989a).

Table 4-1 Performance Data for Barium Wastewaters

Technology	Technology size	Range influent concentration (ppb)	Average effluent concentration (ppb)
Lime Precipitation and Sedimentation	Full	2800	420.00
Lime Precipitation and Sedimentation and Filtration	Full	2800	280.00

Table 4-2 Performance Data for Stabilization of Barium Nonwastewaters

Untreated TCLP (mg/l)	Stabilized TCLP (mg/l)	Accuracy-Adjusted[a] Stabilized TCLP (mg/l)
353	12.32	14.49
2.38	1.01	1.19
353	19.8	23.29
2.38	1.14	1.34
353	6.22	7.32
2.38	0.883	1.04

[a] Accuracy-adjusted by dividing stabilized TCLP concentration by the recovery value of 0.85. Recovery values of 85-115 percent were obtained by matrix spike recovery (USEPA 1989a). The lowest value was used.

5. DETERMINATION OF BEST DEMONSTRATED AVAILABLE TECHNOLOGY (BDAT)

This section presents the Agency's rationale for determining best demonstrated available technology (BDAT) for D005 wastewaters and nonwastewaters.

To determine BDAT, the Agency examines all available performance data on demonstrated technologies to determine (using statistical techniques) whether one or more of the technologies perform significantly better than the others. The technology that performs best on a particular waste or waste treatability group is then evaluated to determine whether it is "available." To be available, the technology must (1) be commercially available to any generator and (2) provide "substantial" treatment of the waste, as determined through evaluation of accuracy-adjusted data. In determining whether treatment is substantial, EPA may consider data on the performance of a waste similar to the waste in question, provided that the similar waste is at least as difficult to treat. If the best technology is not available, then the next best technology is evaluated, and so on.

5.1 Wastewaters

For D005 wastewaters, the Agency has identified lime precipitation followed by sedimentation and filtration as the "best" treatment. The selection of this treatment is based on the performance data on chemical precipitation from EPA's Office of Water, as discussed in Section 4.

5.2 Nonwastewaters

For D005 nonwastewaters, the Agency has identified stabilization as the "best" treatment. The selection of stabilization is based on

performance data on stabilization as a demonstrated technology. These data are discussed in Section 4.

EPA has determined that the best demonstrated technologies specified above for the D005 treatability groups (i.e., lime precipitation followed by sedimentation and filtration for wastewaters; stabilization for nonwastewaters) are commercially available and provide substantial treatment. Hence, these technologies represent BDAT for D005 wastewaters and nonwastewaters, respectively.

EPA has determined that the BDAT for treatment of D005 organobarium wastes is incineration (a demonstrated technology for the destruction of organics) followed by stabilization or leaching of the residual ash.

6. CALCULATION OF BDAT TREATMENT STANDARDS

In this section, wastewater and nonwastewater D005 treatment standards, based on the performance of the applicable BDAT, are developed.

6.1 Wastewaters

The BDAT for D005 wastewaters is lime precipitation followed by sedimentation and filtration. EPA recognizes, however, the diversity of wastes that qualify as hazardous under the D005 classification. Because of this diversity, EPA has chosen to regulate D005 wastewaters at the characteristic level of 100 mg/l. EPA believes even the most difficult to treat D005 wastewaters can be treated to this level.

6.2 Nonwastewaters

The BDAT for D005 nonwastewaters is stabilization. The available data, which are presented in Section 4, show that a treatment standard of 52 mg/l is achievable for nonwastewater in TCLP leachates. The calculation of the standard is presented as Table 6-1. EPA does not believe that these data--which are very sparse--adequately represent the diversity of wastes covered by the characteristic. Because of this diversity, EPA has chosen to regulate D005 nonwastewaters at the characteristic level of 100 mg/l (see Table 6-2). EPA believes even the most difficult to treat D005 nonwastewaters can be treated to this level.

Table 6-1 Calculation of Achievable Treatment Standard for D005 Nonwastewaters

Constituent	Accuracy-adjusted treated waste concentrations[a] (mg/l) (TCLP)	Mean of accuracy-adjusted concentrations (mg/l) (TCLP)	Variability factor	Treatment standard (mg/l)
Barium	14.49[b]	15.03	3.5	52

a Data were adjusted by dividing the treated waste concentration by the recovery value of 0.85. Recovery values of 85-115 percent were found by matrix spike recovery (USEPA 1989a). The lowest value was used.

b Only those data sets where the untreated TCLP concentrations are above the characteristic level of 100 mg/l were used in the calculation of the treatment standard.

Table 6-2 BDAT Treatment Standards for D005 Wastes

Constituent	Maximum for any single grab sample	
	Wastewater (mg/l)	Nonwastewater TCLP/mg/l)
Barium	100	100

7. P013

This section addresses regulation of the only P waste that is listed for barium. This waste, P013 - barium cyanide, is identified in 40 CFR 261.33 as "discarded commercial chemical products, off-specification species, container residues, and spill residues thereof." Treatment standards for cyanides in P013 wastes were promulgated in the Final Rule for Second Third Wastes (54 FR 26614, June 23, 1989). Detailed information on the development of cyanide treatment standards for P013 wastes is found in the BDAT Background Document for Cyanide Wastes (USEPA 1989c). This section addresses only the development of a treatment standard for barium in P013 wastes.

7.1 Industries Affected

Barium cyanide is prepared by the reaction of barium hydroxide with hydrocyanic acid in water followed by low-temperature evaporation under vacuum (Jenks 1978). Barium cyanide is used in the metallurgy and electroplating industries (Hawley 1981). Additional information on the industries affected by the land disposal restrictions for barium wastes is presented in Section 2.1.

7.2 Applicable and Demonstrated Treatment Technologies

The treatment technologies described in Section 3 as being applicable and demonstrated for D005 barium wastes are also considered to be applicable and demonstrated for P013. EPA has no data suggesting that other treatment technologies are applicable or demonstrated for P013 wastes.

7.3 Determination of Best Demonstrated Available Technology

The Generator Survey data base listed barium concentrations from 10-100 ppm to 50-75 percent (USEPA 1986b). The concentrations of barium in barium cyanide fit within this range and therefore could show similar treatabilities.

EPA believes that P013 wastes, as commonly generated, are similar to D005 wastes. Therefore, the Agency expects P013 wastes to be generated as wastewaters or to be easily dissolvable in water prior to treatment. The solubility in water of barium cyanide is 800 g/l (Weast 1977). Because barium cyanide is very water soluble, the Agency believes that the best way to treat nonwastewater forms of P013 is to dissolve them in water (if they are not already dissolved) and then treat them by a technology applicable to wastewaters.

The Agency has identified lime precipitation followed by sedimentation and filtration as the "best" treatment for P013 wastewaters. These technologies were part of the treatment train used as BDAT for regulating the cyanide content of P013 (USEPA 1989c). However, EPA is not regulating P013 wastewaters for barium but only for cyanides (USEPA 1989c). EPA believes that the treatment train used to treat P013 wastewaters for cyanides will effectively reduce the concentration of barium at the same time.

For P013 nonwastewaters, the Agency has identified stabilization as the "best" treatment. EPA has also determined that the best demonstrated technologies specified above for P013 wastewaters and nonwastewaters are commercially available and provide substantial treatment. Hence, these technologies represent BDAT for P013 wastewaters and nonwastewaters.

7.4 Selection of Regulated Constituents

EPA is not regulating for barium in P013 wastewaters, only for cyanides. Treatment standards for cyanides in P013 wastes were promulgated in the Final Rule for Second Third Wastes (54 FR 26614 June 23, 1989). Barium and cyanides are the only BDAT list constituents that the Agency expects to find in the wastes on a regular basis (unless these wastes are mixed with other listed hazardous wastes, in which case other treatment standards would also apply). Note that barium and cyanides are the only Appendix VIII constituents for which P013 wastes are listed.

7.5 Calculation of Proposed Treatment Standards

P013 wastewaters are being regulated for cyanide but are not being regulated for barium (USEPA 1989c). The Agency has identified lime precipitation followed by sedimentation and filtration as the "best" treatment for P013 wastewaters. These technologies were part of the treatment train used as BDAT for regulating the cyanide content of P013 (USEPA 1989c). However, EPA is not regulating P013 wastewaters for barium but only for cyanides. EPA believes that the treatment train used to treat P013 wastewaters for cyanides will effectively reduce the concentration of barium at the same time.

For P013 nonwastewaters, the Agency believes that stabilization is BDAT. The treatment standard for P013 nonwastewaters is calculated in Table 7-1. The treatment standard for P013 nonwastewaters is presented in Table 7-2. Stabilization data have been transferred from D005 nonwastewaters to P013 nonwastewaters because of the expected similarities of both wastes (after cyanide treatment). EPA has no data suggesting that another standard would be applicable.

Table 7-1 Calculation of Achievable Treatment Standard for D005 Nonwastewaters

Constituent	Accuracy-adjusted treated waste concentrations[a] (mg/l) (TCLP)	Mean of accuracy-adjusted concentrations (mg/l) (TCLP)	Variability factor	Treatment standard (mg/l)
Barium	14.49[b]	15.03	3.5	52

a Data were adjusted by dividing the treated waste concentration by the recovery value of 0.85. Recovery values of 85-115 percent were found by matrix spike recovery (USEPA 1989a). The lowest value was used.

b Only those data sets where the untreated TCLP concentrations are above the characteristic level of 100 mg/l were used in the calculation of the treatment standard.

Table 7-2 BDAT Treatment Standard for P013 Wastes

Constituent	Maximum for any single grab sample	
	Wastewater (mg/l)	Nonwastewater TCLP (mg/l)
Barium	NR[a]	52

NR = Not regulated.

[a]P013 wastewaters are not being regulated for barium but are being regulated for cyanides. See the Best Demonstrated Available Technology (BDAT) Background Document for Cyanide Wastes (USEPA 1989c).

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